2014 Fall Outlook for Central & Northern New Mexico

Previous observations and climate prediction model forecasts which lead us to believe that a strong El Niño was going to materialize by late summer or early Fall have all but disappeared. Current observations and the consensus among climate forecasters suggest that a weak to moderate El Niño is the much more likely outcome this fall or early winter. The general rule of thumb when discussing precipitation in New Mexico during an ongoing or forecast El Niño is that it will be above to well above average. A closer look at precipitation data at sites throughout central and northern New Mexico with respect to previous weak-moderate El Niño events, however, reveals that precipitation in September, October and November is not that far above 30-yr averages, particularly when September precipitation is removed.

“Typical” El Niño Pattern

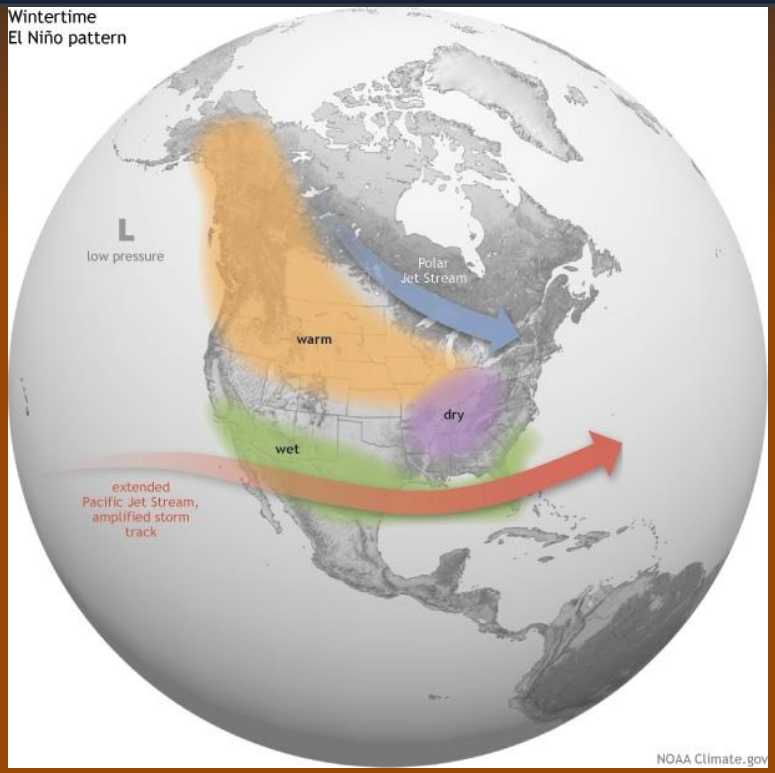
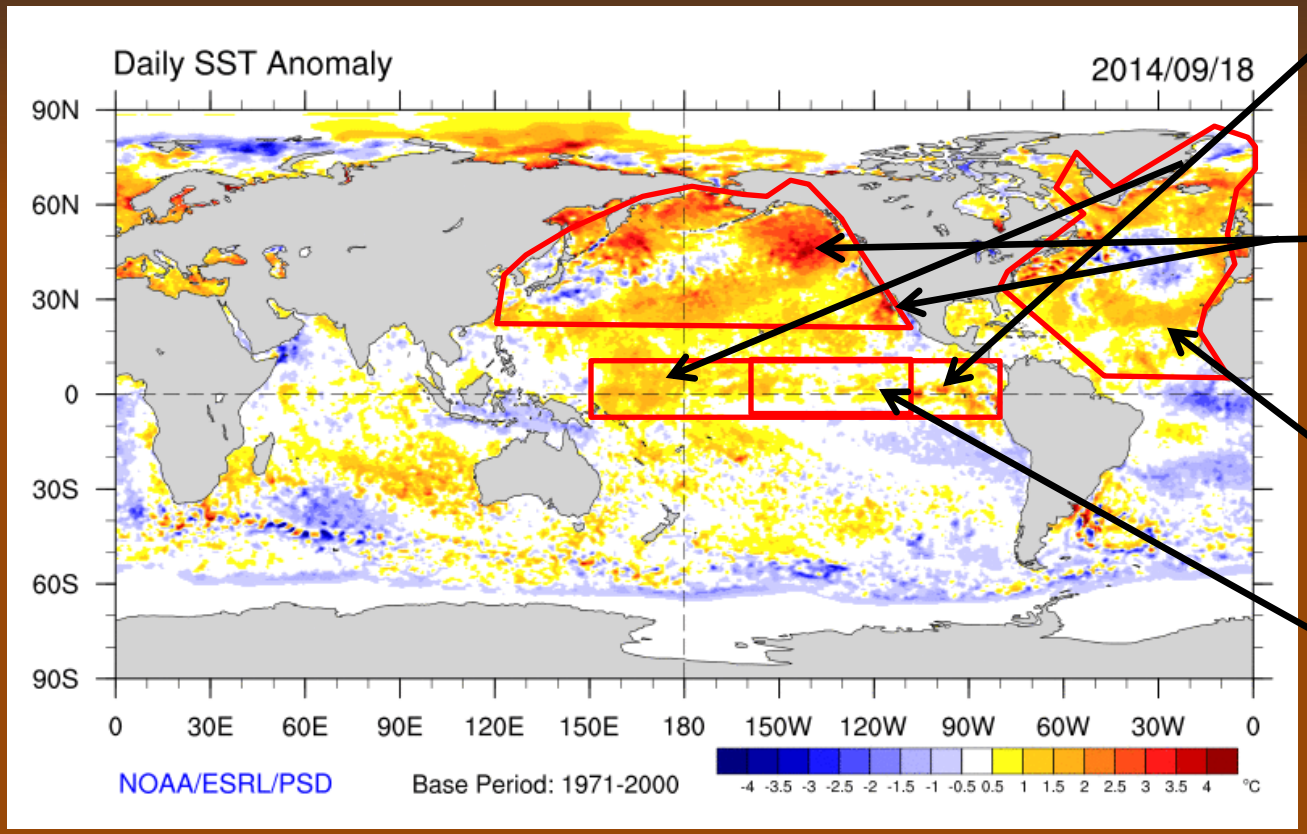


Figure 1. This is the typical upper level pattern we expect toward the end of the Fall season during a weak to moderate El Niño. Warmer than average sea surface temperatures (SSTs) in the central and eastern Pacific Ocean result in more deep convection over these areas. The Pacific Jet stream becomes stronger and once it moves east of the deep convection, seeks balance and splits near the west coast of North America. The southern portion of the split is, at times, stronger than the northern portion and can be more active as well, with an increased storm track over the southwest United States. This southern portion of the split is often referred to as the sub-tropical jet stream.

Latest Sea Surface Temperature Observations & Oscillation Index Values



- Multivairate ENSO Index (MEI) for JUL-AUG 2014: +0.86
- Pacific Decadal Oscillation (PDO) for AUG 2014: +0.67
- Atlantic Mutidecadal Oscillation (AMO) for AUG 2014: +0.36
- Oceanic Niño Index (ONI) (uses Niño 3.4 region) for JJA 2014: +0.0

Figure 2. Recent SST Anomalies in the Equatorial Pacific Ocean do not presently lend themselves to a strong El Niño, with a weak or weak-moderate event the much more likely result at this time. Therefore, comparisons to past strong El Niño years (1982 & 1997) have been left out of this outlook.

Sub-surface Observations

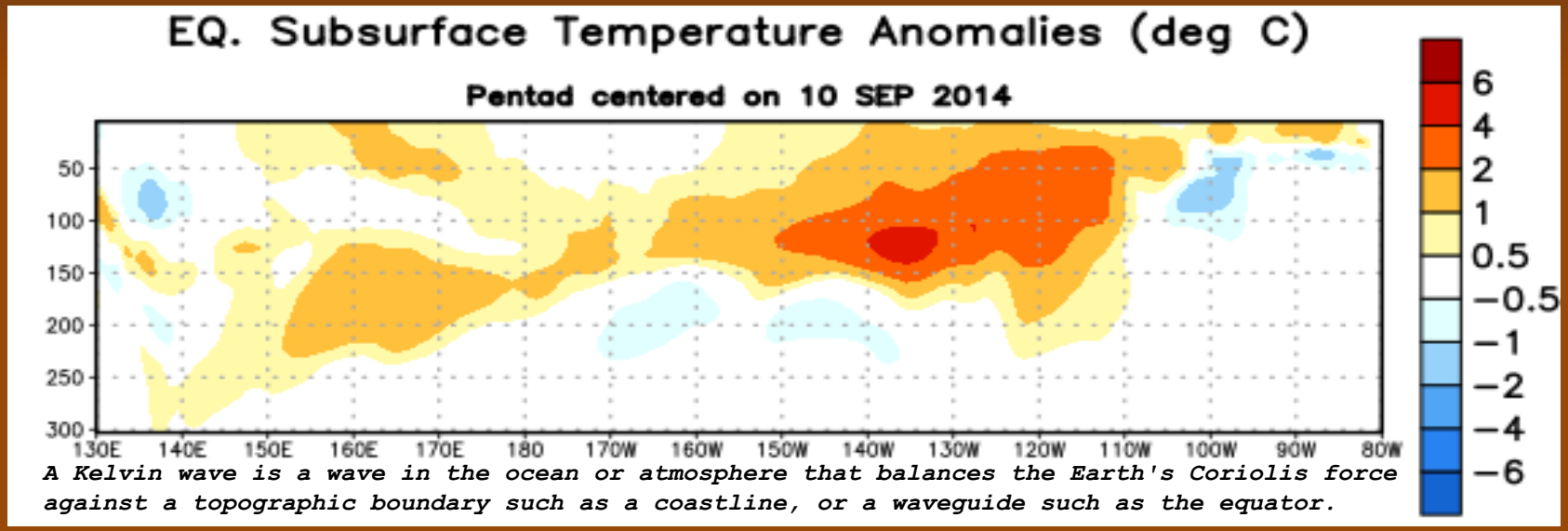


Figure 3. Sub-surface Equatorial Pacific plots indicating that another area of warm water associated with a Kelvin wave will be surfacing in the eastern Pacific Ocean shortly. This is encouraging data which indicates that at least moderate Kelvin wave activity in the equatorial Pacific was continuing into late Summer.

Latest Sea Surface Height Anomalies in Pacific

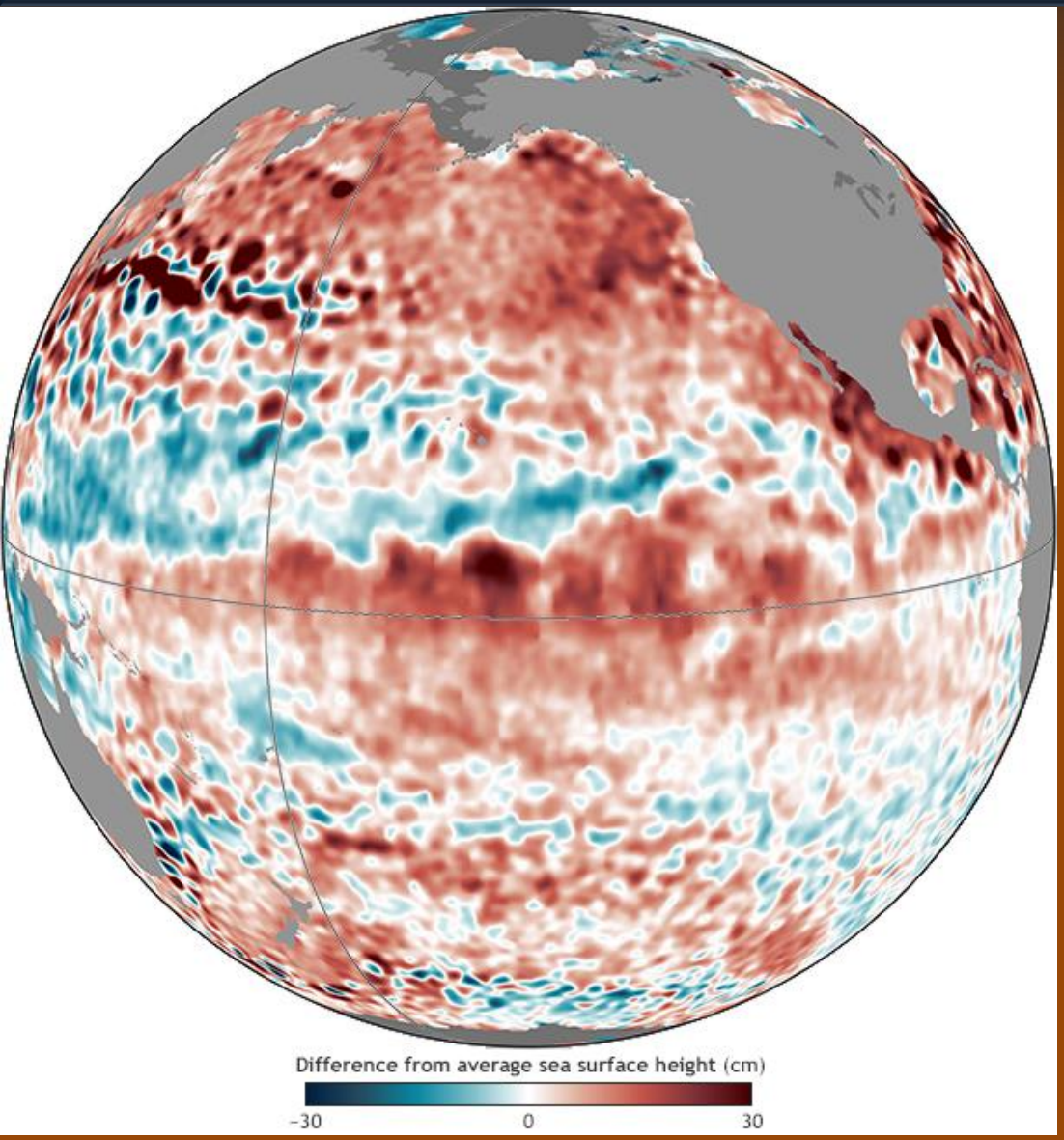


Figure 4. Sea surface height anomaly averaged over August 20-30, 2014. Higher-than-average sea-surface height indicates warmer waters below the surface; the current upwelling Kelvin wave is visible along the equator as an especially dark red spot near image center. Image by NOAA Climate.gov from JASON-2 satellite data provided by NOAA View.

When will El Niño materialize?

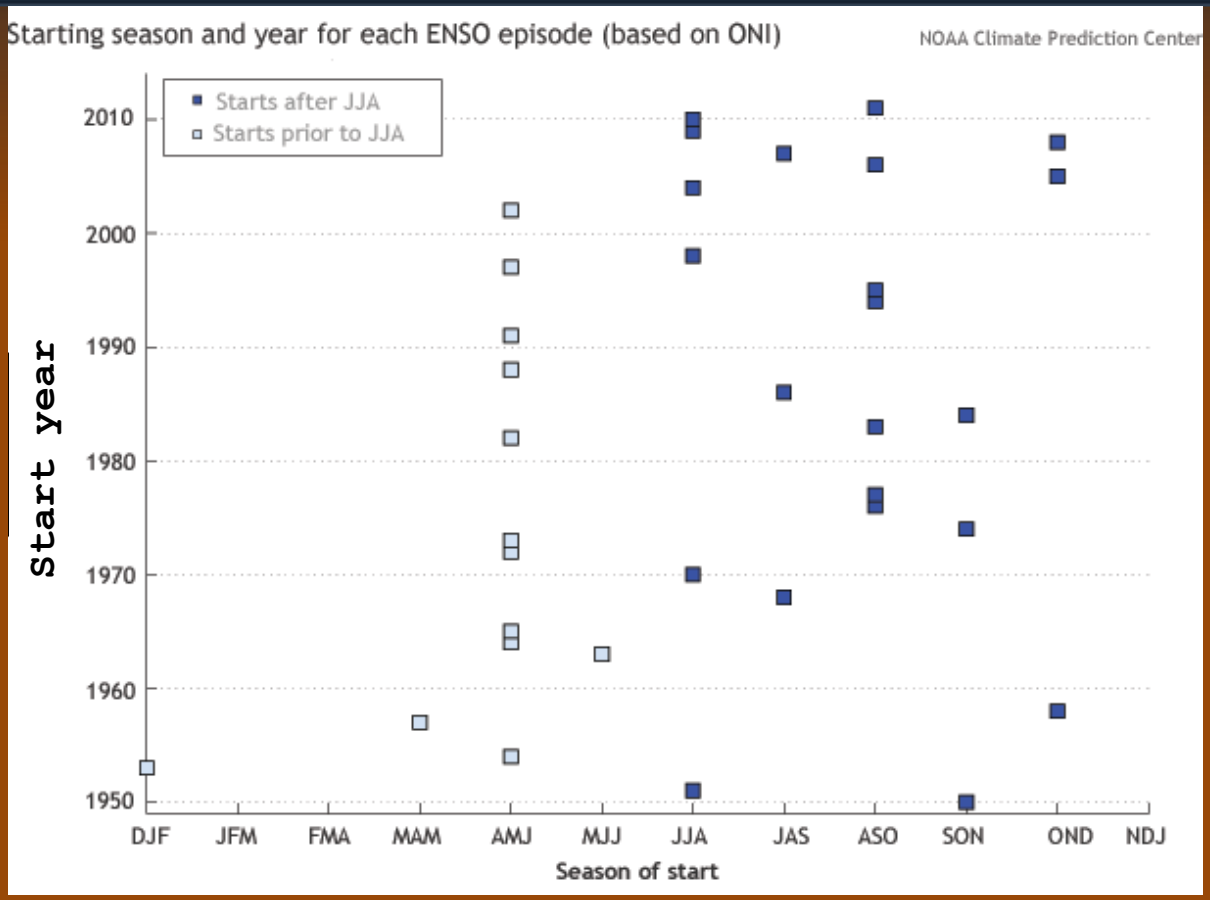


Figure 5: Looking at the record of Oceanic Niño Index values (seasonal or 3-month averages in the Niño-3.4 region) going back to 1950, there is considerable variation in the start time of the approximately 33 individual ENSO events. April-May-June (AMJ) is the most frequent month during which the threshold for El Niño or La Niña was crossed. During the past decade, though, while ENSO has been very active, no events have begun before June-July-August (JJA), with two of the eight events starting in August-September-October (ASO), and two events as late as October-November-December (OND).

Analog Years

Year	DJF	JFM	FMA	MAM	AMJ	MJJ	JJA	JAS	ASO	SON	OND	NDJ
MEI 1986	-0.309	-0.194	0.33	-0.166	0.322	0.316	0.389	0.811	1.168	0.996	0.872	1.183
MEI 1991	0.308	0.306	0.393	0.445	0.718	1.14	1.009	1.01	0.736	1.017	1.201	1.321
MEI 2002	-0.53	-0.213	-0.201	0.342	0.801	0.882	0.613	0.928	0.805	0.953	1.059	1.105
MEI 2006	-0.474	-0.457	-0.591	-0.686	-0.018	0.565	0.637	0.760	0.793	0.893	1.29	0.947
MEI 2009	-0.755	-0.720	-0.719	-0.157	0.375	0.934	0.949	0.957	0.761	1.021	1.062	1.003
MEI 2014	-0.318	-0.269	-0.017	0.152	0.932	0.878	0.816	0.858				

Year	DJ	JF	FM	MA	AM	MJ	JJ	JA	AS	SO	ON	ND
ONI 1986	-0.5	-0.4	-0.2	-0.2	-0.1	0.0	0.3	0.5	0.7	0.9	1.1	1.2
ONI 1991	0.3	0.2	0.2	0.3	0.5	0.7	0.8	0.7	0.7	0.8	1.2	1.4
ONI 2002	-0.2	0.0	0.1	0.3	0.5	0.7	0.8	0.8	0.9	1.2	1.3	1.3
ONI 2006	-0.9	-0.7	-0.5	-0.3	0.0	0.1	0.2	0.3	0.5	0.8	1.0	1.0
ONI 2009	-0.8	-0.7	-0.5	-0.2	0.2	0.4	0.5	0.6	0.8	1.1	1.4	1.6
ONI 2014	-0.6	-0.6	-0.5	-0.1	0.1	0.1	0.0					

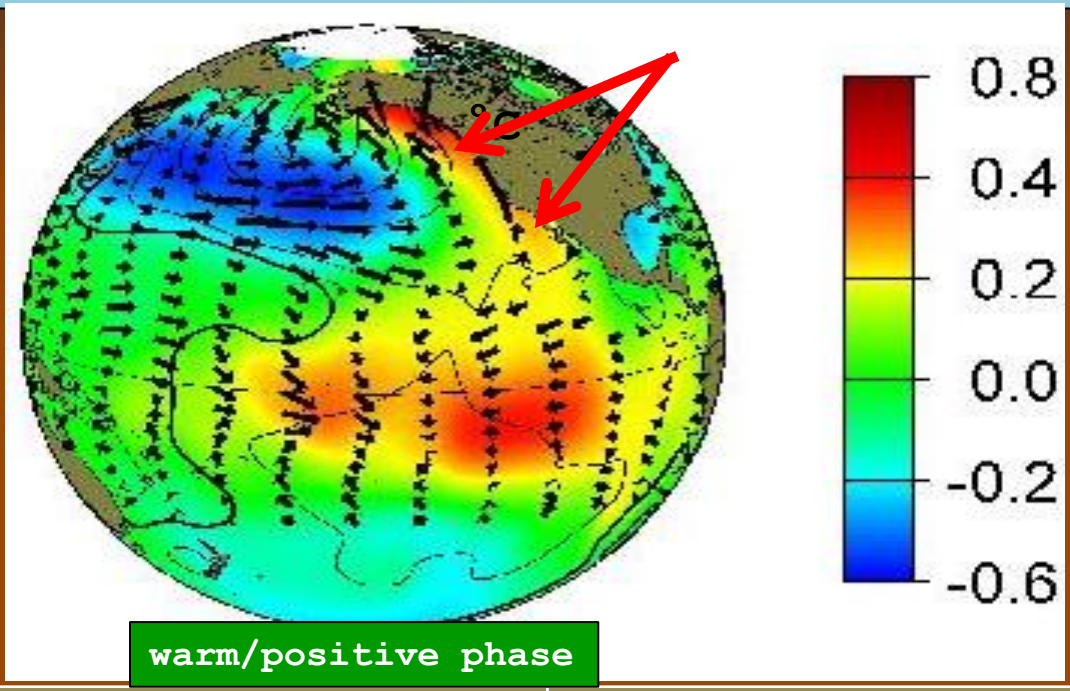
Year	J	F	M	A	M	J	J	A	S	O	N	D
PDO 1986	1.12	1.61	2.18	1.55	1.16	0.89	1.38	0.22	0.22	1.00	1.77	1.77
PDO 1991	-2.02	-1.19	-0.74	-1.01	-0.51	-1.47	-0.10	0.36	0.65	0.49	0.42	0.09
PDO 2002	0.27	-0.64	-0.43	-0.32	-0.63	-0.35	-0.31	0.60	0.43	0.42	1.51	2.10
PDO 2006	1.03	0.66	0.05	0.40	0.48	1.04	0.35	-0.65	-0.94	-0.05	-0.22	0.14
PDO 2009	-1.40	-1.55	-1.59	-1.65	-0.88	-0.31	-0.53	0.09	0.52	0.27	-0.40	0.08
PDO 2014	0.30	0.38	0.97	1.13	1.80	0.82	0.70	0.67				

Year	J	F	M	A	M	J	J	A	S	O	N	D
AMO 1986	-0.320	-0.252	-0.270	-0.302	-0.206	-0.238	-0.226	-0.250	-0.197	-0.296	-0.375	-0.348
AMO 1991	-0.175	-0.097	-0.049	-0.113	-0.134	-0.110	-0.088	-0.090	-0.018	-0.243	-0.242	-0.195
AMO 2002	0.200	0.184	0.164	0.046	-0.029	-0.098	-0.047	0.125	0.099	0.130	0.038	0.024
AMO 2006	0.143	0.095	0.080	0.217	0.328	0.353	0.394	0.421	0.384	0.354	0.309	0.191
AMO 2009	-0.038	-0.144	-0.139	-0.110	-0.041	0.142	0.249	0.173	0.078	0.185	0.090	0.103
AMO 2014	-0.040	-0.021	-0.059	-0.072	0.020	0.084	0.243	0.356				

Figure 6. Oceanic indices from weak to moderate El Niño onset years compared with 2014. Note that while 2006 and 1986 are the most analogous to 2014, there are no previous onset El Niño years since 1980 where all four oceanic indices match 2014 values.

The Pacific Decadal Oscillation (PDO) Review

A key factor during a positive PDO is increased low and mid level moisture availability in far northeast Pacific/Gulf of CA.



PDO Jan, Feb, Mar, Apr, May, Jun, Jul, Aug 2014	PDO Jan, Feb, Mar, Apr, May, Jun, Jul, Aug 2006
0.30, 0.38, 0.97, 1.13, 1.80, 0.82, 0.70, 0.67	1.03, 0.66, 0.05, 0.40, 0.48, 1.04, 0.35, -0.65

Figure 7. Typical Sea Surface Temperature Anomaly (SSTA) patterns and windstress (arrows) in the North Pacific Ocean during a positive Pacific Decadal Oscillation phase (PDO). As with the North American Monsoon season, SON precipitation correlates well with positive PDO values. The closest analog calendar year to 2014 since 1980 was 2006.

September, October and November (SON) precipitation in weak-moderate & moderate El Niño Years vs. 30-yr Avg.

Green = Above 30-yr Avg Orange = Below 30-yr Avg.

Site	81'-10' avg Sept-Nov	2009 El Niño=weak-mod PDO=slightly pos	2006 El Niño=weak-mod PDO=slightly neg	2002 El Niño=weak-mod PDO=pos	1991 El Nino=weak-mod PDO= slighlty pos	1986 El Niño=weak-mod PDO=pos
ABQ	2.67″	2.97″	2.82″	2.56″	3.62″	3.36″
Santa Fe	3.82″	4.18″	3.74″	4.39″	3.86″	7.71″
Clayton	3.38″	2.78″	1.57″	5.97″	4.86″	7.76″
Gallup	2.99″	3.68″	3.53″	4.48″	3.34″	4.74″
Las Vegas	4.11″	3.29″	2.63″	4.92″	3.94″	7.85″
Roswell	3.35″	2.02″	4.92″	4.07″	5.17″	11.30″
Chama	6.31″	5.81″	8.34″	8.72″	7.05″	11.71″
Eagle Nest	3.44″	4.76″	4.10″	5.06″	4.79″	5.02″
Los Alamos	4.55″	4.08″	3.56″	5.12″	5.64″	7.22″
Taos	3.25″	1.72″	3.62″	4.79″	4.43″	4.78″
Wolf Canyon	5.56″	4.29″	4.93″	7.23″	10.14″	7.97″
Carrizozo	3.48″	5.52″	5.71″	4.35″	3.36″	7.91″
Luna R. S.	4.80″	2.58″	6.23″	5.88″	5.68″	6.13″
El Morro	3.51″	3.00″	3.29″	6.29″	3.96″	5.47″

Figure 8. Note that the vast majority of sites were above average in SON when the PDO index was positive (PDO index average for SON was 1.0 or higher). This rather crude dataset would indicate that El Niño or warmer than average sea surface temperatures (SSTs) of at least 0.5°C has a lower correlation with respect to precipitation in central and northern New Mexico during SON.

How do weak to weak-moderate El Niño events impact Autumn (SON) in central and northern New Mexico?

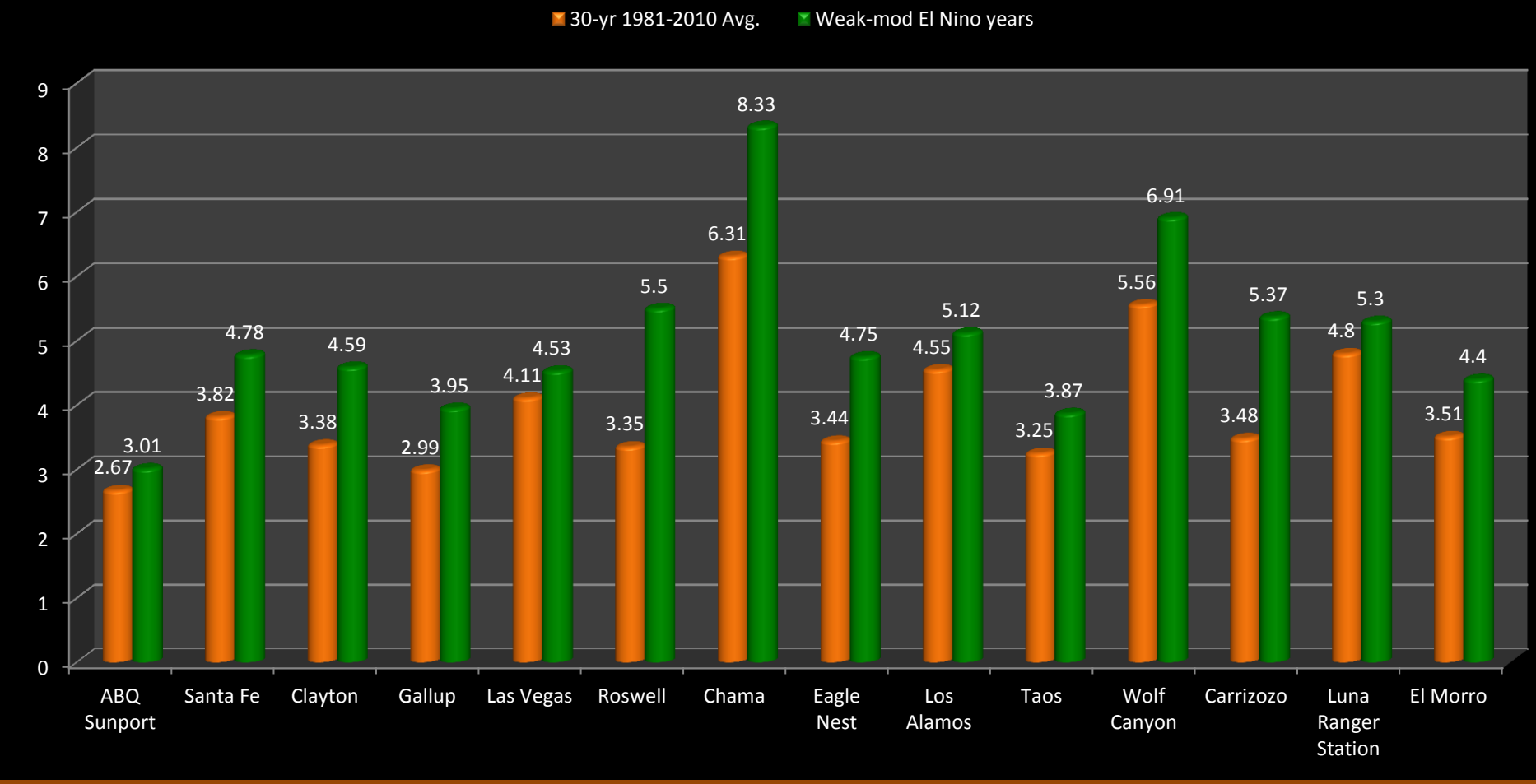


Figure 9. 30-yr climatological averages vs. weak and weak-moderate El Niño years (1986, 1991, 2002, 2006 and 2009). All sites were above average.

How about the top analog PDO/ENSO year to 2014?

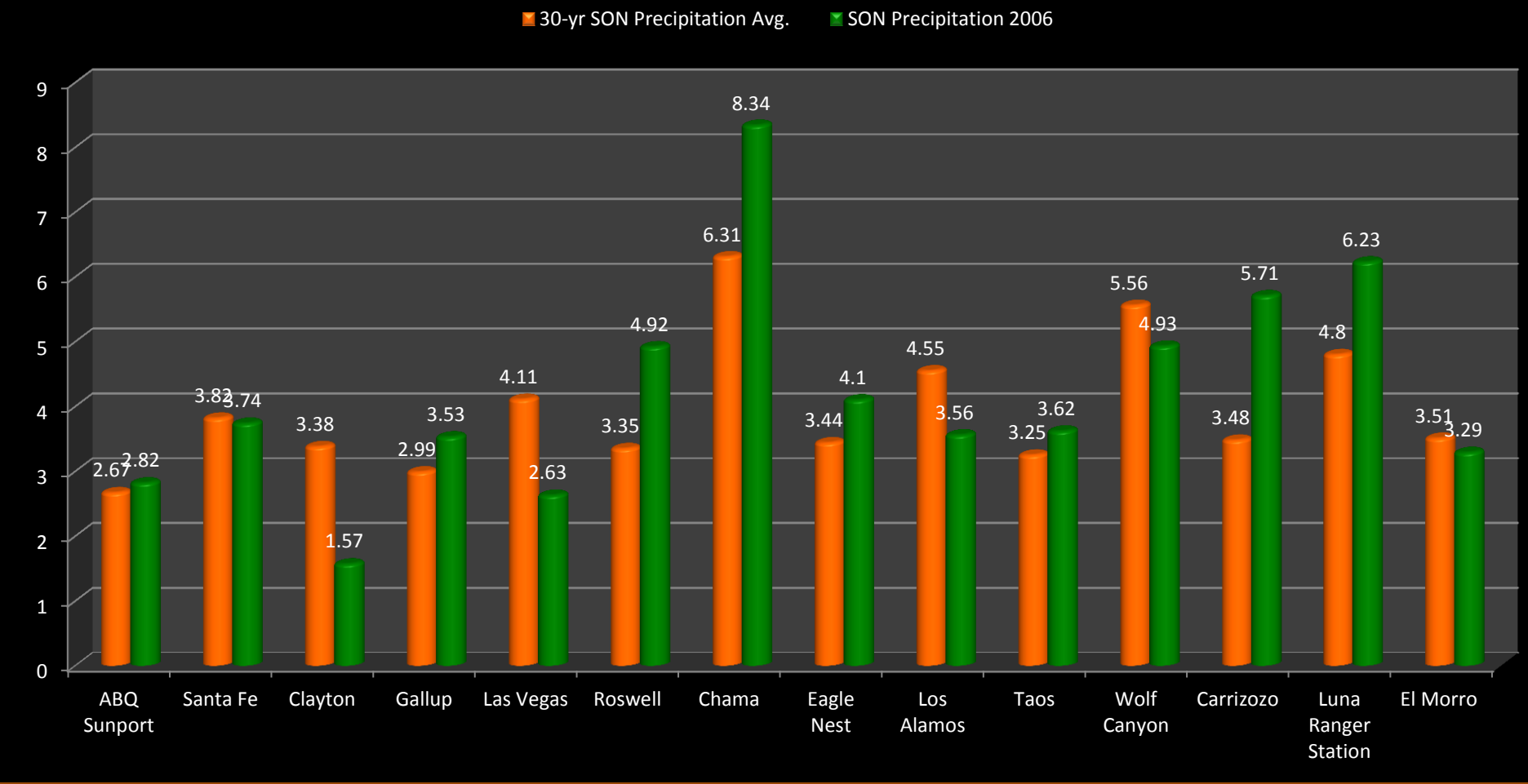


Figure 10. SON 30-yr (1981-2010) climatological averages vs. the closest analog year to 2014 (with regard to MEI/PDO values) January through August, 2006. Many people remember the winter of 2006 but Fall was more varied across the region. Six sites were above average, four sites were very near average, and four sites below average.

Sept-Nov Snowfall

Blue = Above 30-yr Avg | Orange = Below 30-yr Avg.

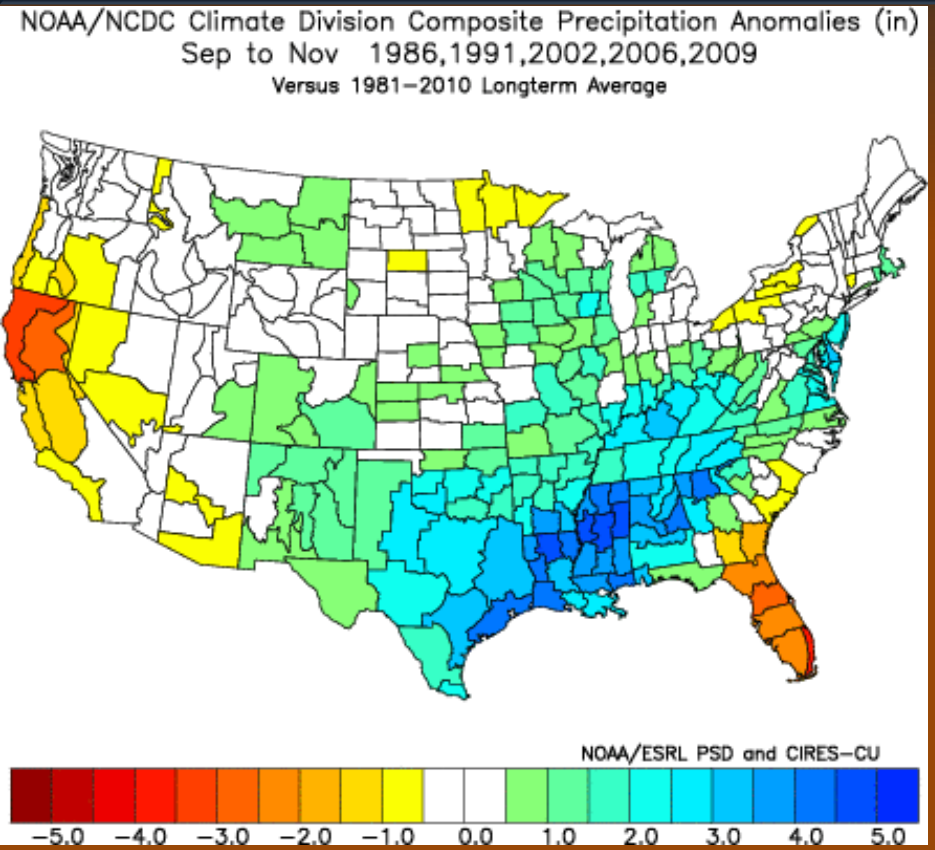
Site	81'-10' avg Sept-Nov	2009 El Niño=weak-mod PDO=slightly pos	2006 El Niño=weak-mod PDO=slightly neg	2002 El Niño=weak-mod PDO=pos	1991 El Nino=weak-mod PDO= slighlty pos	1986 El Niño=weak-mod PDO=pos
ABQ	1.7″	0.8″	0.2″	M	4.0″	3.8″
Santa Fe	3.9″	3.3″	3.5″	1.0″	5.0″	M
Clayton	4.9″	1.3″	3.0″	M	12.0″	6.2″
Gallup	5.6″	1.0″	M	M	18.7″	2.5″
Las Vegas	6.9″	M	M	M	12.4″	14.9″
Roswell	1.8″	T	4.6″	M	1.2″	0.5″
Chama	14.8″	10.5″	4.5″	8.0″	45.4″	16.7″
Eagle Nest	8.2″	13.0″	4.5″	10.5″	17.5″	14.3
Los Alamos	8.0″	2.4″	0.0″	6.6″	19.4″	12.9″
Taos	3.4″	0.0″	6.7″	5.0″	3.0″	5.3″
Wolf Canyon	16.0″	8.0″	8.0″	15.0″	45.5″	25.0″
Carrizozo	0.7″	0.6″	2.0″	0.0″	4.0″	0.0″
Luna R. S.	1.1″	0.6″	T″	0.0″	M	M
El Morro	6.9″	5.7″	6.2″	T″	20.3″	8.9″
Taos Ski Valley	25.4″	21.5″	20.3″	25.3″	41.5″	38″

Figure 11. The signal with respect to a clear snowfall correlation in SON with previous onset El Niño years is not clear cut. Snowfall in SON during the closest analog year to 2014, 2006, was below average at most sites. Perhaps the influence from the Atlantic Multi-decadal Oscillation (AMO) starts to play a bigger role as we move toward winter.

AMO? Yet another oscillation to consider? Say it isn't so

- Earth's climate system is highly complex. After the El Niño Southern Oscillation (ENSO) was defined in the 1960s by Jacob Bjerknes, future climate scientists sought to find similar oscillations in the Atlantic Ocean basin. Schlesinger and Ramankutty identified the Atlantic Multi-decadal Oscillation (AMO) in 1994.
- The AMO index is correlated to temperatures and rainfall over much of North America. Recent climate research suggests that the AMO is related to major droughts in the Southwest United States. When the AMO is in a warm phase, these droughts tend to be more frequent and/or prolonged. Two of the most severe droughts of the 20th century occurred during the positive AMO between 1925 and 1965: The Dust Bowl of the 1930s and the 1950s drought. The current Southwestern US drought (2010-20??) is also correlated with a positive AMO phase.
- While the AMO correlates well with major long term droughts, it should be noted that there are recent examples where the AMO did not correlate well with late fall and particularly winter precipitation. The late fall and winter of 2006 is the primary example. More on this topic in the upcoming winter 2014-2015 outlook.

Precipitation and Temperature Anomalies from Recent El Niño Events



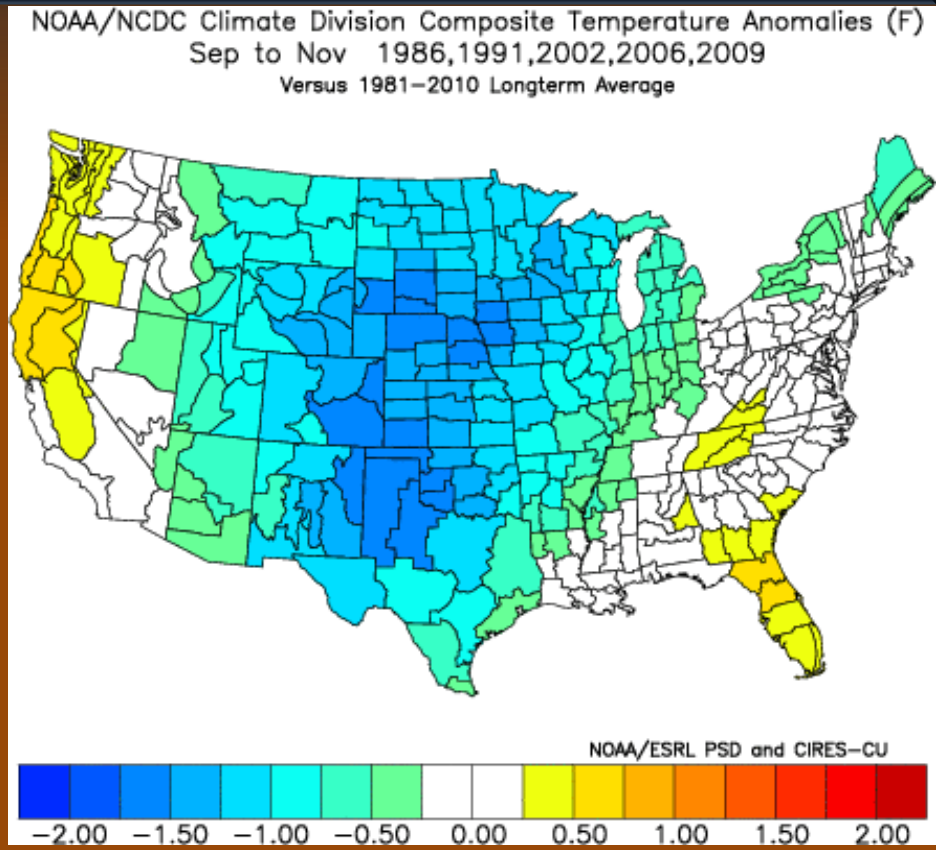
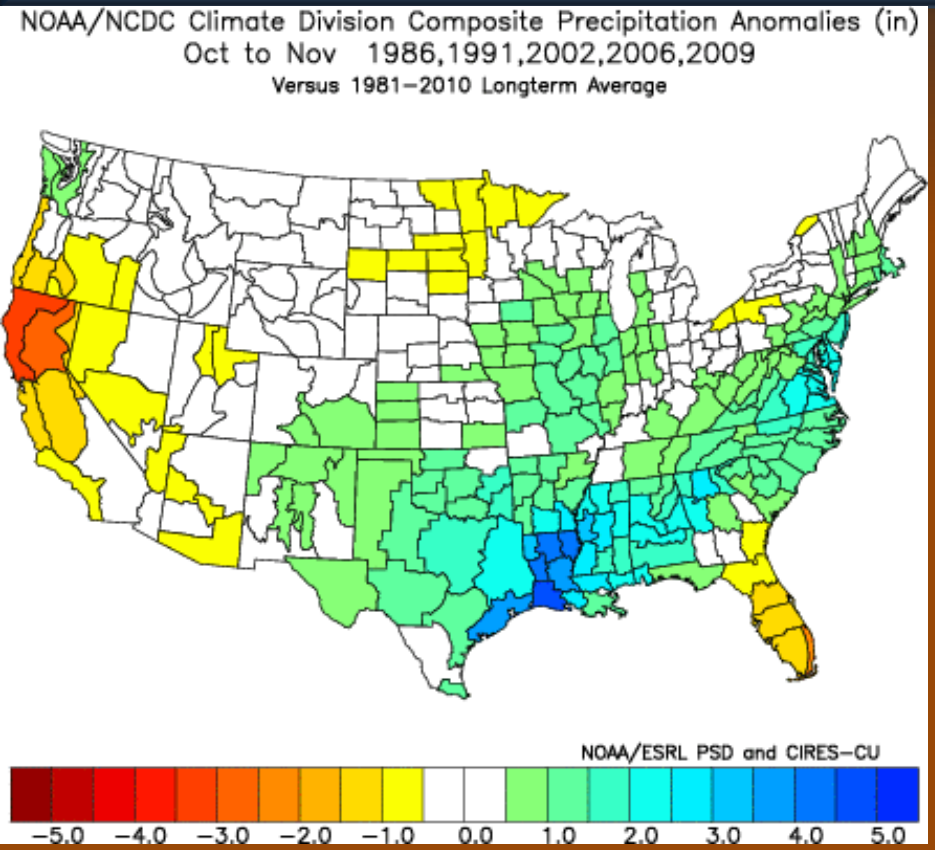


Figure 12. Precipitation and Temperature anomaly plots for CPC's climate divisions comparing weak to moderate El Niño years since 1980 with 30-year climatological averages. All but one climate division in NM is slightly above average for precipitation while the entire state is below average with regard to temperature.

What about just October and November?



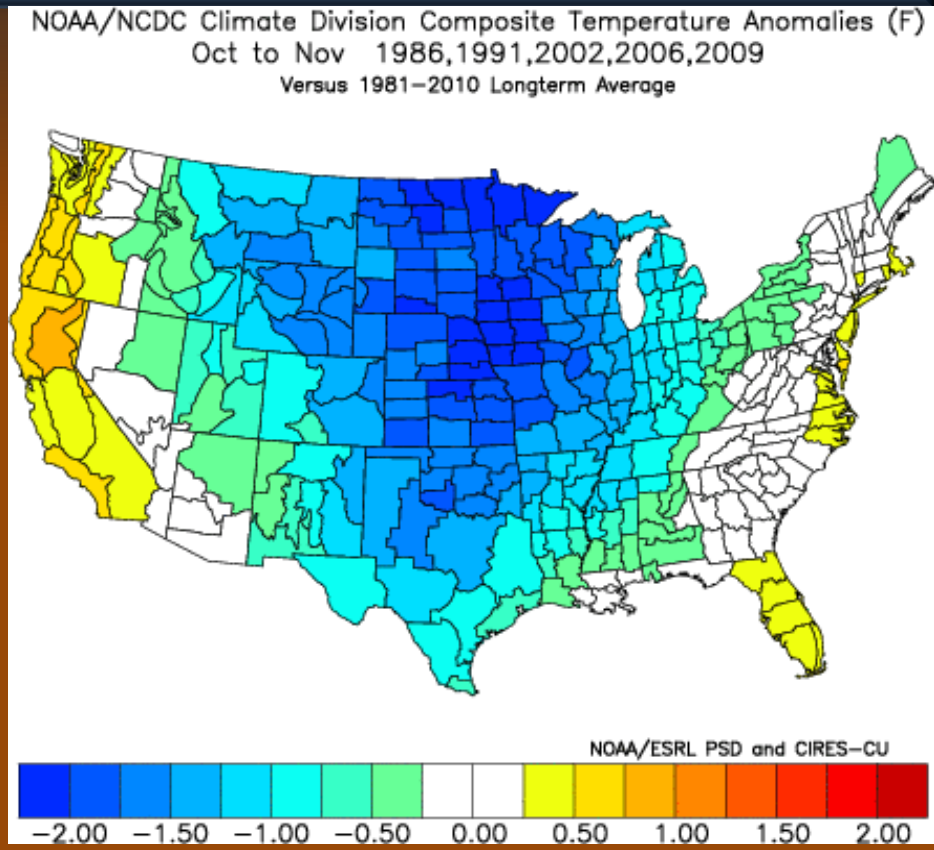
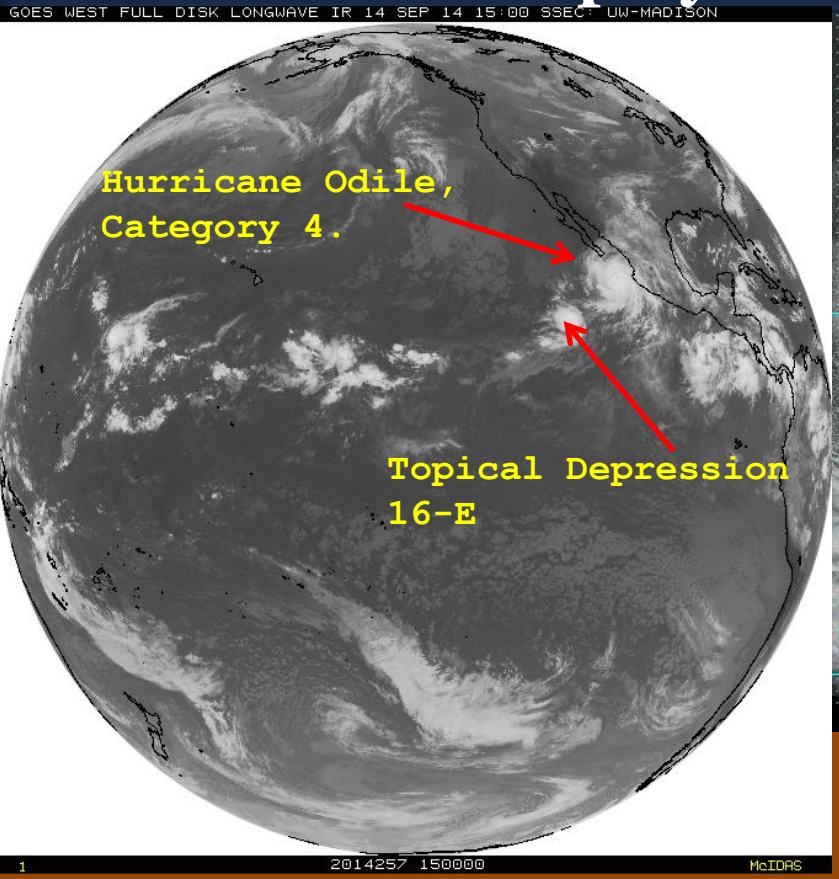


Figure 14: Precipitation and Temperature anomaly plots for CPC's climate divisions comparing weak to moderate El Niño years since 1980 with 30-year climatological averages. When September is removed near to slightly above average precipitation was experienced in previous onset El Niño years. Temperatures were below average, however, over all of the state, particularly the eastern plains.

Hurricane and Tropical Storm remnants can sometimes play a major role in Fall



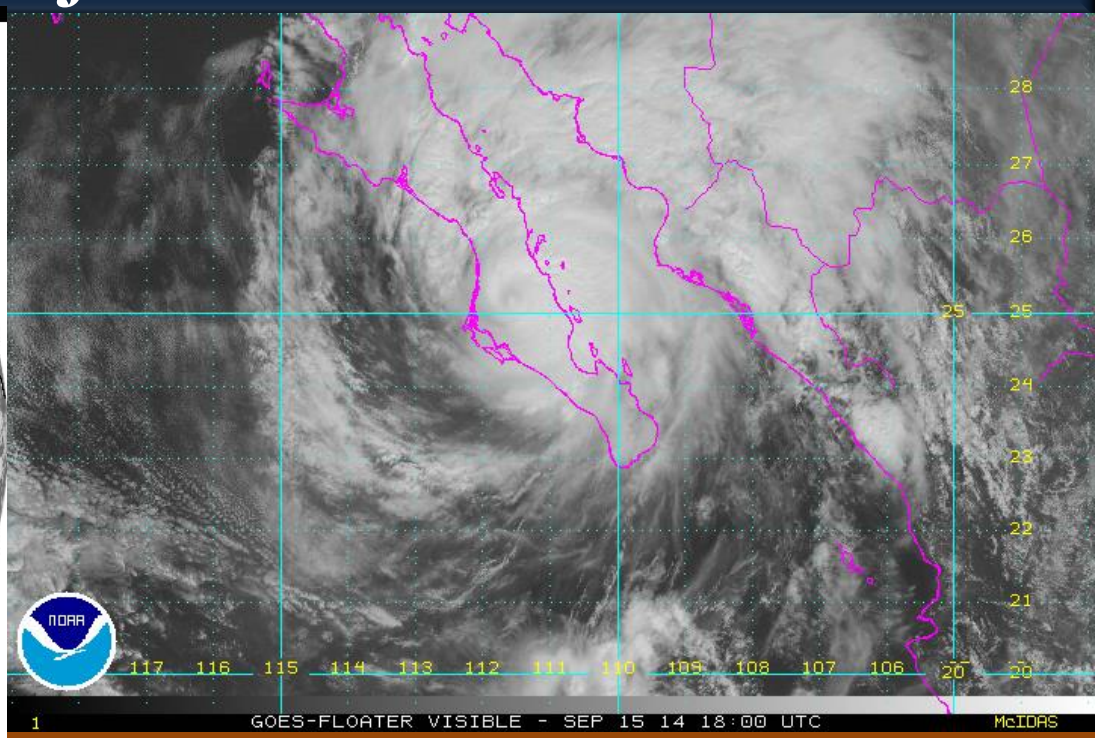


Figure 16. Close up visible satellite imagery of Hurricane Odile, currently a category 2 Hurricane over the Baja peninsula. 12:00 PM MDT SEP 14, 2014.

Figure 15. Hurricane and/or Tropical Storm moisture remnants moving through the southwestern U.S. are most common in early to mid Autumn. Hurricane remnants can bring widespread heavy rainfall to New Mexico in September and October. September has the most hurricane remnants impacting the state with 26 on record. Warmer than average SSTs in far eastern Pacific commonly lead to more Tropical Storm and Hurricane Development. So far in 2014, 16 named storms have formed, 11 hurricanes and 8 major hurricanes.

Current upper level storm track

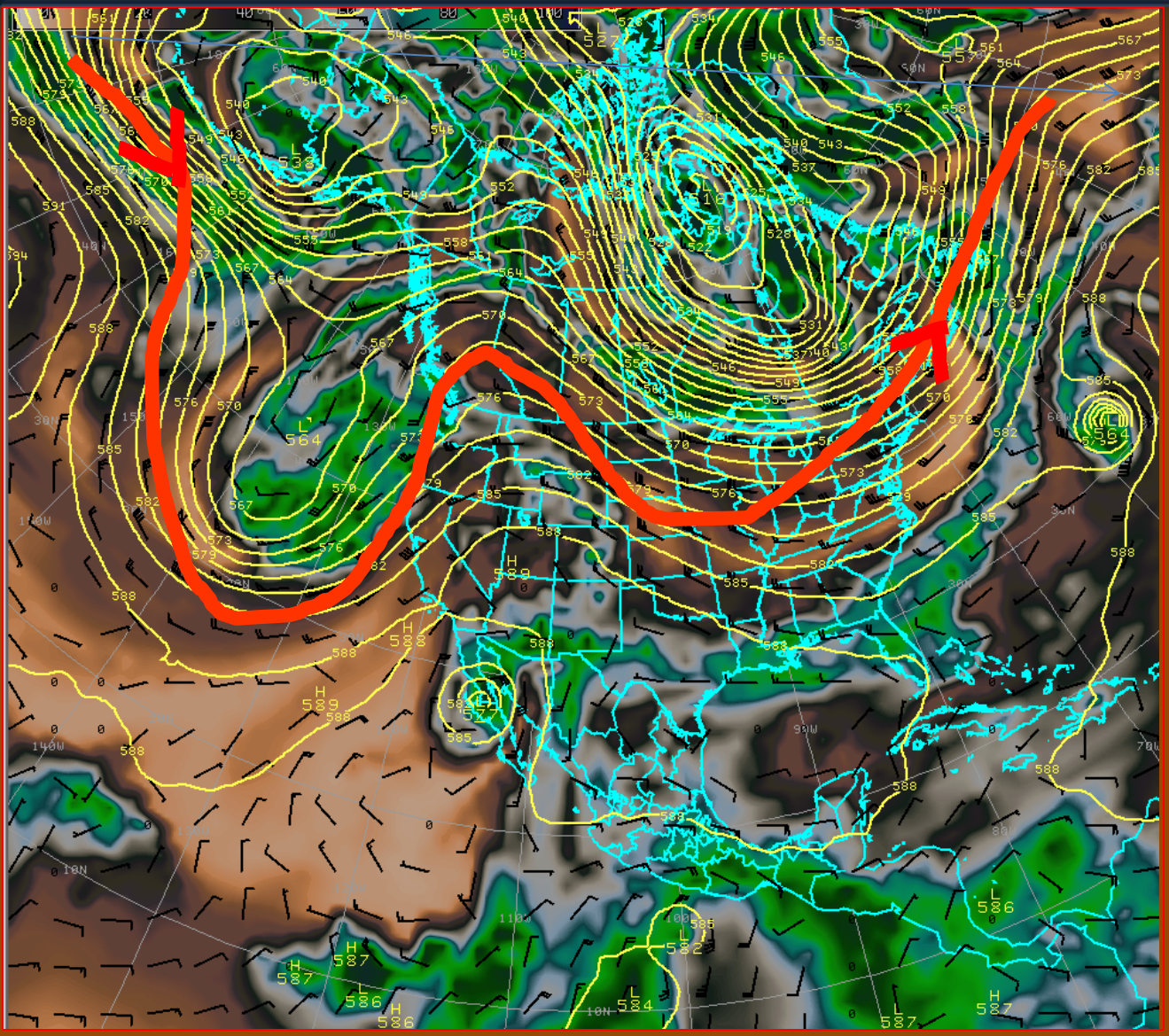
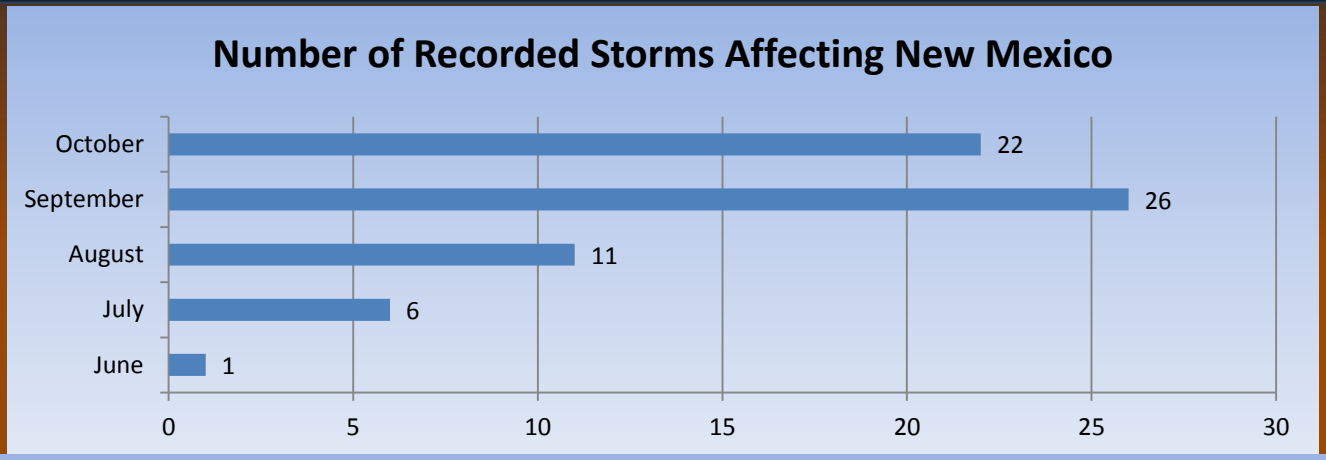


Figure 17. Current Storm Track over and near North America. Note the deep upper level trough off the west coast. This pattern, if it continues, is highly favorable for bringing up deep tropical storm and/or Hurricane remnants from the south or southwest into NM.

Recorded Tropical Storms and/or Hurricane Remnants Affecting New Mexico



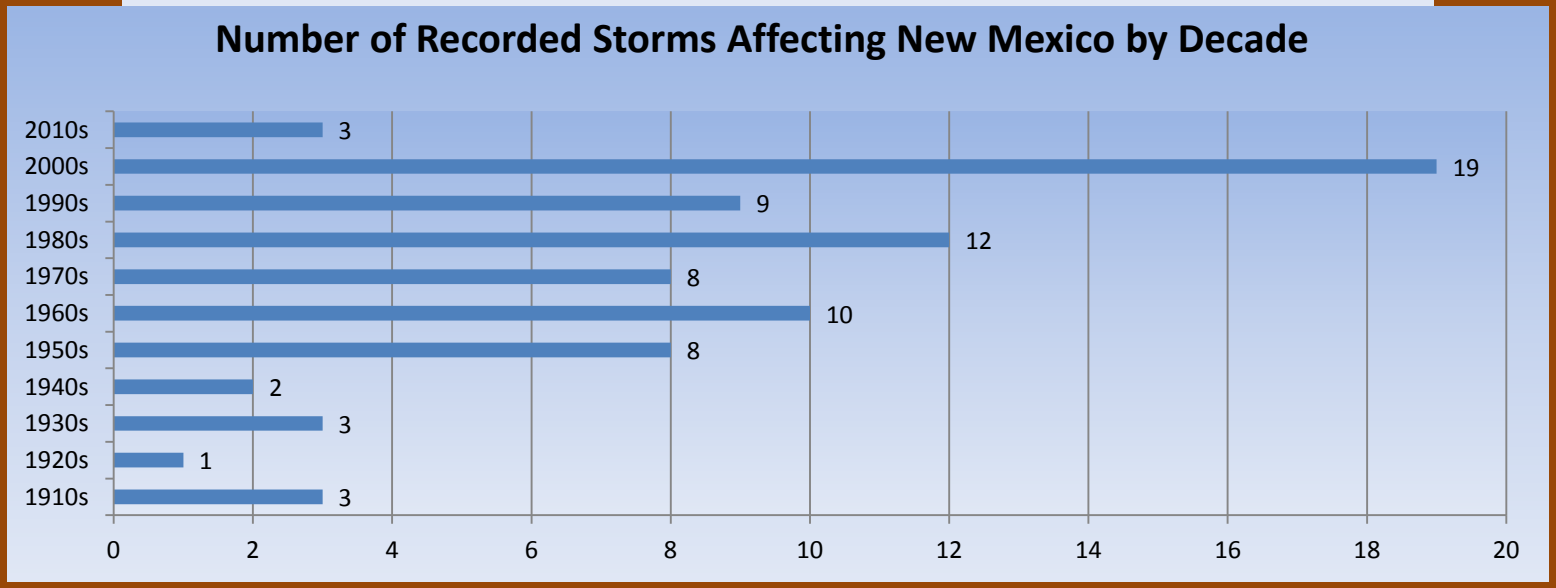
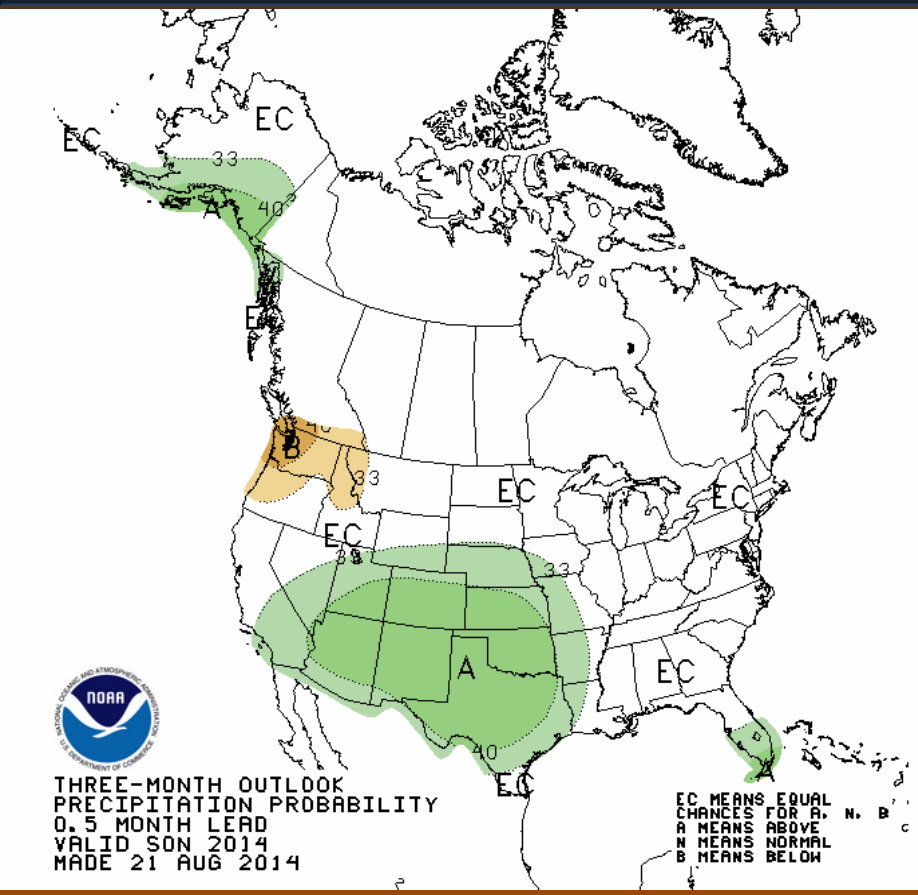


Figure 17. Tropical Storm and Hurricane remnants impacting New Mexico since 1900. Prior to the satellite era/1966, the numbers are unreliable.

Sept-Nov Precipitation & Temperature Outlook from CPC



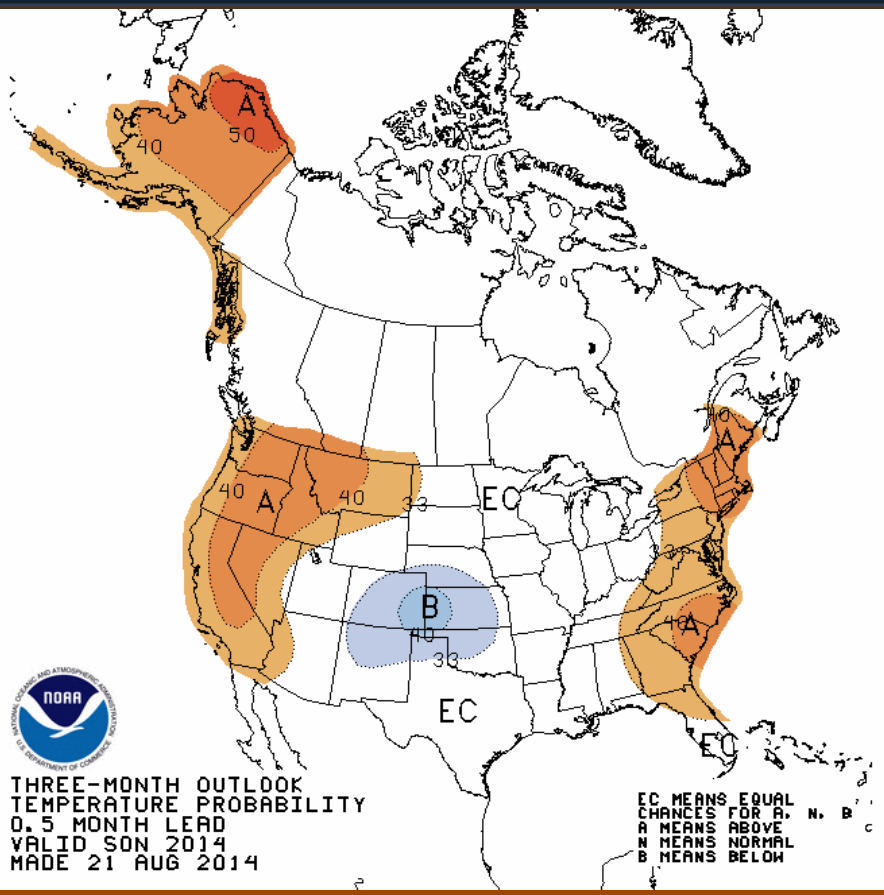


Figure 18. Climate Prediction Center's meteorological Fall (SON) Outlook which incorporates both dynamical climate prediction model data as well as previous precipitation and temperature statistics to derive a seasonal forecast. Greater than average chances for above average precipitation is forecast for the southwestern United States. Slightly higher chances for below average temperatures are forecast for northern half of NM.

Latest Climate Model Forecasts

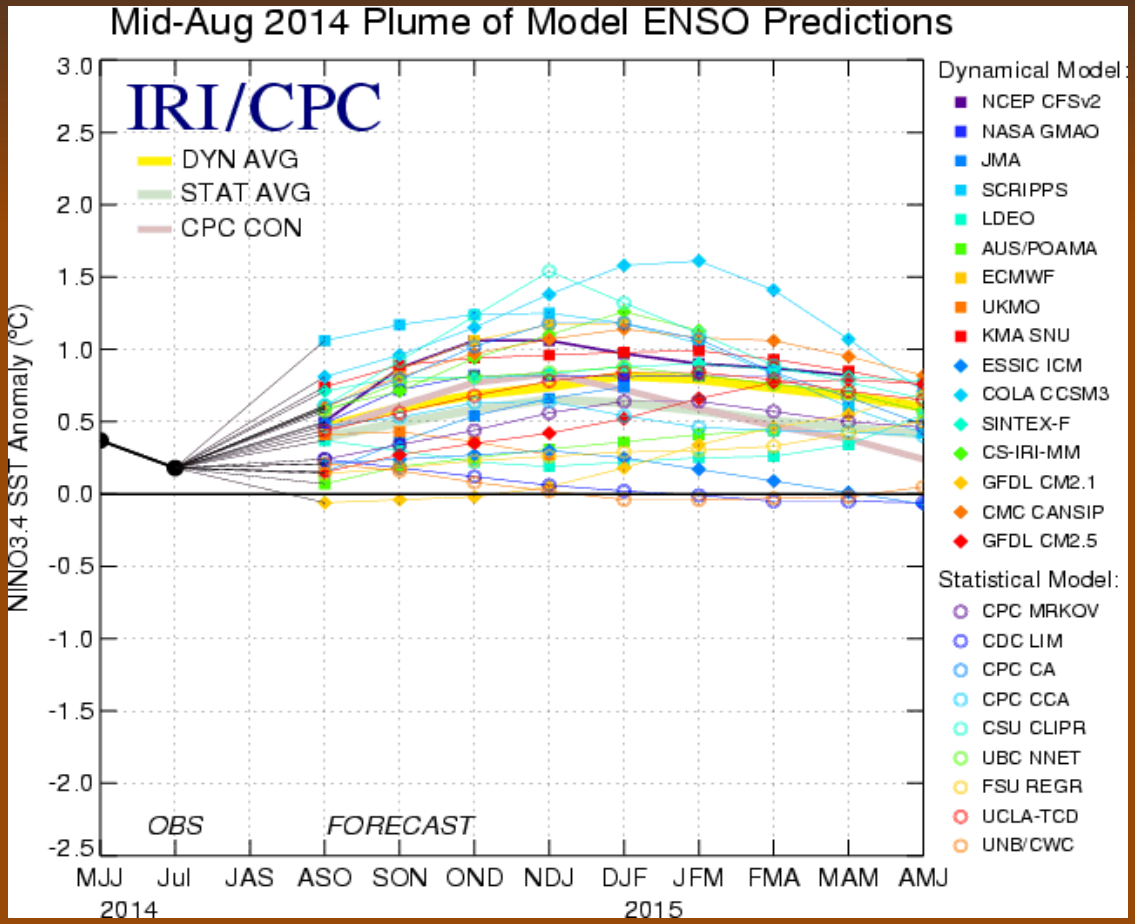


Figure 19. The vast majority of models favor a weak (0.5°C- 1.0°C) El Niño to develop during October-December 2014, persisting through Northern Hemisphere winter 2014-15.

Summary

- Precipitation in previous Fall (SON) seasons during the onset years of a weak-moderate El Niño events since 1980 was above 1981-2010 climatological averages at most sites throughout northern and central New Mexico.

- Precipitation data from previous 5 El Niño onset years of weak-moderate El Niño events indicate that if current SST trends in the eastern Pacific Ocean (particularly an anomalously warm area of SSTs along the Baja California coast southwest of Ensenada) and the current upper level pattern continues to be similar to current conditions into late September and October, probabilities are much greater than normal for SON 2014 precipitation to be above to well above 30-yr climatological averages. Latest Sea Surface and Sub-surface Temperature Anomalies (SSTAs) and climate model forecasts for SSTs in equatorial Pacific Ocean favor a weak-moderate El Niño event beginning sometime in SON.

- Keep in mind that above average precipitation is most common in central and northern NM when a weak to weak-moderate El Niño is present in combination with a positive Pacific Decadal Oscillation (PDO).

- Snowfall data from the previous 5 onset years of weak-moderate El Niño events suggest that no clear signal for either above or below average exists at the sites included in this study. Precipitation and temperature anomalies suggest, however, that backdoor cold fronts may be more common in onset El Niño years (Figures 13 & 14) which would typically favor areas from the east slopes of the central mountain chain eastward to the Texas line for more precipitation and perhaps higher than average snowfall.

- Additionally, when September precipitation is removed from the previous 5 El Niño onset years, October and November precipitation is very near to slightly above the 30-yr (1981-2010) climatological average.

Outlook Information

- Outlook provided by National Weather Service Forecast Office Albuquerque, NM.

- For further information contact Andrew Church: andrew.church@noaa.gov (505)244-9150